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ADDRESS OF THE RETIRING PRESIDENT OF THE SOCIETY IN AWARDING THE BRUCE MEDAL TO SIR F. W. DYSON, ASTRONOMER ROYAL OF ENGLAND

By Charles S. Cushing

For some years past it has been the custom in our Society to elect alternately as its President a professional astronomer and a layman. It is needless to say that my incumbency is during what I might term "layman's year." During the past year I have many times asked myself the question, "Why should a layman be elected President of this Society?" I find difficulty in answering this question in favor of the layman. If a favorable answer is to be given, the reasons of such answer are probably to be found in the fact that a non-professional man may help the Society in its organization, financially, and in the important function of keeping it in touch with the public.

Directly or indirectly our great observatories are supported by the public. Many of our most noted observatories have been founded by men having little knowledge of astronomical science. The layman's function, beyond his mere ability to pay his annual dues, may become quite important in encouraging an interest in astronomy, and thereby indirectly encouraging contributions to the support of scientific institutions, and in tending to excite and keep alive popular interest in the many problems pertaining to astronomical science. The success of our Society, in which we all take a pardonable pride, may be in a measure due to the joint interest of professional and non-professional men.

While the reasons stated why a layman may be of use to the Society may to an extent justify his presence, the cooperation of the professional astronomer is an absolute necessity to the successful conduct of our Society. The esteem in which our publications are held, which is manifest in the ever-increasing demand for them, is entirely due to the zeal, industry and efficiency of the highly skilled group of astronomers which supervises our publication.

During the last years members of our Society have been more than generous in their contributions to astronomical science. A series of lectures of a high order and value was first rendered possible by the generosity of Mr. Adolfo Stahl. During the last two years we have been enabled to continue these lectures through contributions from two other members of our Society. The generosity of these members has been exceeded only by their sense of modesty which has prevented a mention of their names.

I can assert from actual experience that at no time during more than thirty years of our Society's existence has a greater interest been manifest in its lectures and publications than during the past year. In fact, the attendance at the lectures delivered under the auspices of the Society this winter has been the largest in the history of the Society.

The close of the year finds the affairs of the Society in all respects in a satisfactory condition. Notwithstanding the high cost of printing, we have not up to date been compelled to curtail greatly our publications. Our membership list is increasing. The influence of the Society is shown in the demand for its publications and in the attendance at its meetings.

The provisions relating to the award by our Society of the Bruce Medal are too well known to require repetition. The Board of Directors of the Society, pursuant to nominations of the observatories designated under the Bruce Trust, has awarded the Bruce Medal for the year 1922, to Sir F. W. Dyson, Astronomer Royal of England.

While the merits of this selection require no explanation at my hands, it is customary for the retiring President to state the reasons for the award. I freely acknowledge that in making the following brief statement as to Dr. Dyson's contributions to science, I have had the assistance and advice of some of our skilled astronomers.

Our medalist, Frank Watson Dyson, was born in 1868. He studied at Trinity College, Cambridge University, and has received degrees from Cambridge and Edinburgh. He is a Fellow of the Royal Society and has been knighted by the Crown. He became Chief Assistant Royal Astronomer at Greenwich in 1894, and occupied that position until 1905, when he was appointed Royal Astronomer for Scotland and Professor of Astronomy at the University of Edinburgh. He occupied this position until 1910, when he was appointed Astronomer Royal, which includes the directorship of the Royal Observatory at Greenwich, a position which he has since occupied with conspicuous success.

The fact that Dr. Dyson has held successively the important positions enumerated and that at an early age he was called to the position of greatest distinction connected with astronomical science within the gift of his government, speaks volumes for his ability.

The important institution over which he has presided might well claim in its mere routine work all the time of the most industrious and able man. His position has called on him for many administrative duties, but notwithstanding these he has found time to make more fruitful the work actually done by others.

Dr. Dyson's chief contributions have been in the study of the systematic motions of the stars and of stellar distances; and on the bearing of these upon the distribution of the stars in space and the structure of the stellar system. One can hardly imagine a more interesting problem than the determination of the motions of the stars in space and particularly our motion with respect to these stars. Located as we are on a small planet revolving about an ordinary star which is traveling rapidly through space, it is our problem to determine from the observed motions of the other stars, every one of which is also traveling rapidly, the true position in space at any given instant and the true direction of all the stars. In its complete form this problem is entirely beyond our powers, but by the determination of the parallaxes, proper motions and radial velocities of a large number of stars well distributed over the sky, we acquire the materials which by skillful analysis give us at least an approximation to the truth. Dr. Dyson's work on proper motions and parallaxes is a most valuable contribution to the materials for such studies. He has also made even more valuable contributions in the way of studies based upon materials collected by himself and others.

The systematic motions of the stars may be investigated either by observing the radial velocities of the stars—that is, their motions toward or from us in the line of sight—or by observing their motions across the line of sight—that is, their progressive changes of position on the celestial sphere. The latter are called "proper motions" and are determined by comparing accurate positions of the stars, as observed with a meridian or transit circle, or in recent times by photography, at one epoch of time with similar positions observed at a different time. If the observed positions are of the same order of accuracy, the greater the time interval between the two sets of observations, the more accurate the proper motions.

Since a very large part of the work of the Greenwich Observatory has consisted in accurate observations of star positions, particularly of those in the more northern parts of the sky, Dr. Dyson was naturally led to make his investigations chiefly on the basis of proper motions.

As chief assistant at the Royal Observatory, it was his duty to supervise and take part in the regular work of observing star-positions with the meridian instruments, and this work done in the years 1894-1905 consisted in part in re-observing the stars observed in the years 1806-1816 by Groombridge.

It is obvious that carefully made observations, such as those of Groombridge, are of the greatest value, when compared with modern observations covering the same subjects, in determining the movements under consideration.

With the assistance of Dr. W. G. Thackeray, Dr. Dyson carried out this piece of work, which is entitled "New Reduction of Groombridge's Catalogue of Circumpolar Stars, (with W. G. Thackeray) Published in 1905."

The original catalog was compiled from observations made by Stephen Groombridge in the years 1806-1816. It contains 4,239 stars situated in the more northerly part of the sky. The original observations are very carefully made, but the published positions were known to be subject to large systematic errors. To eliminate these as far as possible, by correcting any errors of computation, and to reduce the whole catalog to the system of Newcomb's Fundamental Catalogue for 1900, a complete new reduction of the original observations was undertaken by Dyson and Thackeray.

At the same time, the entire list of stars was re-observed with the accurate modern instruments of the Greenwich Observatory, and the two sets of positions thus obtained at an average interval of nearly eighty years were utilized to determine the changes in position or "proper motions" of the stars. This work was done largely under Dr. Dyson's supervision and with his cooperation in the work itself. It is chiefly in these proper motions, especially of the stars as faint as the 7th magnitude, or fainter, that the value of the work consists. For from them it is possible to derive a new value for the constant of precession and for the direction of the solar motion in space. Kapteyn says that the catalog "by the number of accurate proper motions of small stars which it contains and the care bestowed on its reduction, may safely be considered as the most valuable contribution of material for the study of sidereal motions since the publication of the third volume of Auwer's 'Bradley'."

That the interest in proper motions of stars shown by this early work still continues, may be seen from Dr. Dyson's more recent papers, one of which, for example, bears the title, "Analysis of the Proper Motions of the Reference Stars in the Greenwich Astrographic Catalogue," MONTHLY NOTICES, R. A. S., May, 1920.

Later, he investigated the proper motions and the space distribution of the stars contained in Carrington's Catalogue of the North Polar Stars. This includes practically all stars as bright as the 10th magnitude within 10° of the North Pole. One of the most important conclusions drawn from this latter work was the fact that the vast majority of these stars lay between the distances represented by the parallaxes 0″.005 and 0″.0015, that is, between the distances of about 650 light-years and 2,150 light-years. He also found that these stars showed the division into the two streams, the discovery of which had been Kapteyn's first great contribution to the study of stellar motions.

The stars are found to be divided into two great interpenetrating streams moving, in a general way, nearly parallel to the plane of the Milky Way and in nearly diametrically opposite directions.

If the stars are all moving at random, then the *observed* proper motions of the stars, which are compounded of the stars' own "peculiar" motions and of the Sun's motion through space, should, upon analysis, give the direction of the solar motion, and this direction should always be the same, no matter what stars are investigated, provided only that they be well distributed over the sky. But if many stars have a general drift in one direction, while many others have a general drift in a contrary direction, then the direction of the solar motion depends upon the stars used in its determination. Here again, skillful analysis will enable us to separate the two star streams, as Kapteyn and Eddigton and Dyson and others have done. It then becomes a question whether these two star streams have independent origins and are simply passing through space in contrary directions, or whether they are the effect of a general orbital revolution of all the stars in greatly elongated ellipses. In the latter case, the resulting figure of the stellar system would be a vast ellipsoid, the longer diameters lying in the plane of the Milky Way. Schwarzchild believed in the latter theory and developed what is known as the ellipsoidal hypothesis. Dr. Dyson finds that the motions of the Carrington stars conform rather better to this hypothesis than to the two-drift hypothesis, but he does not regard his results as conclusive proof.

With similar ends in view, Dr. Dyson made a thorough discussion of all the stars in the whole sky whose proper motions were large—exceeding 20 seconds of arc per century. These give results clearly confirming the division of the stars into two streams, and give the vertexes of their motion in good agreement with those found by Kapteyn and Eddington on the basis of different material.

Among other results obtained by Dr. Dyson from such studies of proper motions is that the stars of larger proper motions—say motions greater than 6″ (six seconds of arc) per century, lie, in the main, in the near region of space; those with small proper motions—say 3″ or less per century, in the main, in the more distant regions of space. The former show little tendency to crowd toward the Milky Way, the latter show this tendency very markedly. This effect is doubtless a consequence of the fact that star density is greatest in the region near us and diminishes as we move outward, but diminishes far more rapidly in the directions of the Poles of the Galaxy than in the directions lying in the plane of the Milky Way.

Dr. Dyson's results were based first on a dicussion of the stars in the Cambridge Catalogue for the zone + 24° to + 32° and confirmed later by a similar discussion of the stars in Boss's Preliminary General Catalogue, which includes the brighter stars in the entire sky.

According to Einstein's theory of generalized relativity, a ray of light passing near the limb of the Sun should be deviated from its original direction, by the Sun's gravitational field, by an amount equal to $1''.75 \frac{R,}{R,}$ where R is the radius of the Sun and R_1 the distance from the ray to the Sun's center. Obviously an experimental test of the reality of the predicted displacement is afforded by the comparison of the positions of the stars in a field whose center is occupied by the Sun, with the positions of the same stars when the Sun is not in this star field. Early in 1917 Dr. Dyson called the attention of the Royal Astronomical Society to the fact that the total eclipse of the Sun of May, 1919, afforded a specially favorable opportunity for making this test owing to the unusual number of bright stars in the field and the proximity of some of them to the Sun. Acting upon his suggestion, the Joint Permanent Eclipse Committee sent expeditions to Sobral in North Brazil and to the island of Principe to secure these observations. The planning and organization of these two expeditions was a specially difficult task with the nation utilizing all its resources and men in the prosecution of a great war; and that the plans were carried through to success was largely due to the tireless efforts of Dr. Dyson in the organization and direction of the work, and the efficient cooperation of the observers, Dr. Crommelin and Mr. Davidson at Sobral and Professor Eddington and Mr. Cottingham at Principe. The results of these observations, while perhaps not entirely conclusive, are, as is well known, in harmony with the deflection of 1″.75 at the Sun's limb predicted by Einstein's theory. Largely on Dr. Dyson's initiative, an expedition is being sent to Christmas Island to observe the eclipse of September 20, 1922. The chief object is to check the results described above.

Among the other notable works undertaken by Dr. Dyson may be mentioned the following:

Under his administration the Royal Observatory at Greenwich has taken an ever more prominent part in modern forms of research. To illustrate this, Greenwich is the only European observatory that is associated with the Yerkes, Mt. Wilson, Allegheny, McCormick and other American observatories in the work of determining stellar parallaxes under the general scheme developed by the Parallax Committee of the American Astronomical Society. Dr. Dyson is directing this work and taking an active part therein, and the Greenwich parallaxes, of which more than one hundred have now been published, rank with the very best so far obtained.

The great Astrographic Star Catalogue covering the sky from + 64° to the North Pole, which was begun by his predecessor, Sir W. Christie, has been completed under his direction, and he has supervised and taken part in the discussion of proper motions based upon the data derived from comparing these places (and particularly those of the special catalog of Reference Stars for measuring the astrographic plates), with those determined at earlier epochs. All these researches and others of similar nature bear evidence of Dr. Dyson's capacity for skillfully handling large masses of data and for the keenness of his analytical powers. They illustrate also his organizing ability, for in such large pieces of work it is necessary to have collaborators and to plan the work so that all details will receive due attention, and at the same time not be so magnified as to obscure a proper vision of the work as a whole. Dr. Dyson seems to have this organizing faculty highly developed.

It requires the knowledge of a specialist to appreciate the skill required to complete the tasks enumerated, which have been performed by our medalist. The highest zeal and skill over a lifetime of unceasing toil are necessary to accomplish such results. I submit that the achievements enumerated in this brief statement amply sustain the action of our board in awarding this medal to Dr. Dyson.

The skilled astronomer working with instruments, the very names of which are unknown to the average man, is considering questions which belong largely to other worlds than ours. We can well imagine him as being not of this world, but as belonging rather to the infinite realms of space.

In concluding my remarks I shall refer briefly to the human side of Sir F. W. Dyson:

It was my pleasure to have met Dr. Dyson in connection with this Society during one of his visits to San Francisco; and later my wife and I had the pleasure of being entertained by him and his very delightful family at the official residence at Greenwich.

Surely, Greenwich is an interesting place replete with historic associations. The observatory stands on a substantial eminence, one of the most marked in the neighborhood of London, and overlooks the bends of the Thames, the city of London itself and Black-Heath, made famous by Wat Tyler's rebellion. The older structures connected with the observatory date from the time of Charles II, and the gardens still show the design of Lenotre, famous French landscape gardener of Louis XIV, who came from France to design them.

The visitor's interest in site and buildings is lost on meeting the genial astronomer and his family. We found Sir F. W. Dyson keenly interested in the events of the day, but most of all in his chosen profession and its problems. All these he discussed with modesty and simplicity, which are the attributes of true capacity. Personally, I shall ever remember with pleasure the honor and privilege of having been enabled to visit the observatory at Greenwich and of having been entertained by this delightful man.

Appropriate steps will be taken to have this token of appreciation presented to our medalist, and it is my wish and hope that he may long live to enjoy his honors so fairly won.